SOIL SURVEY OF THE SACRAMENTO AREA, CALIFORNIA.

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LOCATION AND BOUNDARIES OF THE AREA.

The Sacramento area lies partly within and partly adjacent to the southeastern portion of the Sacramento Valley. This valley, drained by the Sacramento River, a stream navigable for about 200 miles above its mouth, is a very important physiographic feature, and forms the northern half of the great interior valley of California.

The area mapped embraces the territory covered by the topographic and geologic work of the United States Geological Survey and published as the Sacramento sheet, the limits of which are meridians 121° and 121° 30′ west longitude, and parallels 38° 30′ and 39° north latitude. It contains about 924 square miles, and embraces important fruit-producing lands of the Sierra Nevada foothills, as well as large tracts extending outward to the valley trough devoted to dairying, stock raising, and the production of grains, hops, wine and table grapes, fruits, vegetables, and various other products of the orchard and farm.

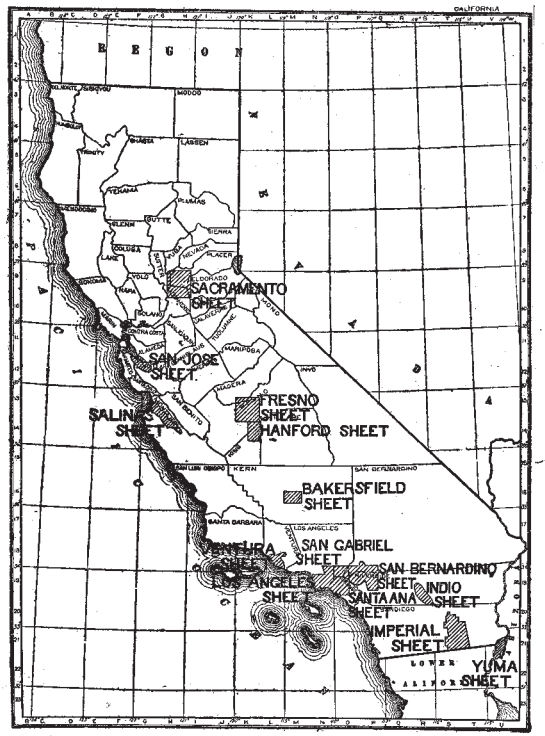

FIG. 43.—Sketch map showing location of the Sacramento area, California.

HISTORY OF SETTLEMENT AND AGRICULTURAL DEVELOPMENT.

During the Mexican régime, between the years 1822 and 1846, a few white settlers, explorers, and adventurers found their way into this section. In certain cases they received large grants of land from the Mexican Government. Among those so favored was Gen. John A. Sutter, who in 1839 built Sutter's Fort on the present site of the city of Sacramento. In 1844 he founded the first settlement, at Sutterville, 3 miles below the fort, on the Sacramento River. Here he planted small plats of wheat, tobacco, and a few fruit trees and vines.

With the discovery of gold in 1848, and the subsequent coming of the gold seekers, stores and trading posts were established. Sutterville was abandoned, and Sacramento, at the site of the historic fort, became the halting place of the steamboat and wagon train and the main outfitting point for the mines. Small surrounding mining towns and settlements, notably those of Auburn, Ophir, Folsom City, and Lincoln, sprang into prominence, farms multiplied, population increased, and the organization of civil districts took place rapidly.

In early days a few flocks and herds of sheep and cattle were brought across the Plains, and, as they rapidly increased, the foundation of a great live-stock industry was laid. Large tracts of Government land were purchased at slight cost, and many of the large Mexican grants were acquired for grazing purposes. Later the growing populations of the mines and towns and the invention of labor-saving farm machinery turned the attention of the holders of these large tracts to the production of grain.

For many years exploitation rather than development was the ruling passion. Mining was carried on with a restless zeal, and there was little indication of a future agricultural development. Whole fields and hillsides were cut with unsightly gashes and pits or removed bodily and sluiced into the ravines and canyons to be washed by the flood waters into the valleys below. Farms were covered with débris, and the stream channels were filled with sand and gravel. Unrestricted hydraulic mining was finally prohibited by law, but with every passing flood the harvest of débris—" slickens," as it is called—still goes on.

Stage and express lines were early established between the towns and the principal mines, and a railroad, the first in the State, was built connecting Sacramento, Folsom City, and Lincoln. This was followed in 1869 by the completion of the first overland railroad, the Central Pacific, to Sacramento, which remained the terminus for some time.

Many of those who came for gold, being disappointed, turned their attention to farming. This population was drawn largely from

eastern States, but was augmented by many foreigners from all parts of the civilized world. Recent immigration has emphasized the cosmopolitan phase of the population.

The growing of grapes, hops, tree fruits, and small fruits began in a small way as early as the sixties. The possibility of successful orange culture, however, was not fully demonstrated until many years later, and it was not until the period from 1888 to 1890 that the production of all kinds of fruit received its greatest stimulus and eastern shipments in large quantities began. The clearing of the brush-covered slopes and planting to orchards and vineyards, and the transition from the extensive grain ranches to small intensively cultivated tracts, is still in progress.

CLIMATE.

The climate of the Sacramento area, like that of the whole northern and central interior of California, is semiarid. Two seasons—the wet and the dry—occur. Light or moderate rainfall, mild winters, warm or hot summers, low relative humidity, and light wind movement are the prevailing climatic conditions, which correspond closely with those of the citrus belt of northern Italy.

The average annual precipitation over the area surveyed varies from about 20 inches in the valley to 40 or more inches in the higher foothills. The rainy season usually begins about the middle of October and continues until the middle of May, although the dates fluctuate widely. The greater proportion of the annual rainfall, however, takes place from November to March, inclusive. The rains are sometimes heavy, but usually fall in steady or gentle showers. They are very rarely accompanied by violent winds, thunder, or lightning, and cloudbursts are almost unknown. Destructive floods during periods of heavy precipitation sometimes occur, but these are the result of topographic conditions rather than excessive rainfall. During the months of April and May showers only occasionally occur. During the summer there is no precipitation of importance, frequently none at all. Snow or hail at any season of the year is of very rare occurrence.

The average annual temperature varies but slightly throughout the area, although it becomes slightly lower in the higher foothills. At Sacramento it is about 60° F., at Rocklin about 62° F., and at Auburn a fraction above that at Sacramento. During the winter frosts occur frequently in the valley and higher foothills, but are less severe and less frequent in the "thermal belt," extending along the foothills with an elevation of from 200 to 1,400 feet, within which zone the cultivation of citrus fruits is possible. While the average annual temperature here is about the same as that of the

citrus-producing sections of southern California, the summer temperature is somewhat higher, forcing the fruit to an earlier maturity. The oranges are sometimes slightly frosted, but the trees are seldom damaged. Late spring frosts rarely occur, and damage to early fruit from this cause is infrequent. During the summer the days are frequently hot, with a temperature sometimes of from 90° F. to 100° F., or more; the nights, however, are usually cool and pleasant. The average annual range in temperature at Sacramento is about 88° F.

The following table shows the normal monthly and annual temperature and precipitation at Sacramento, Rocklin, and Auburn:

Normal monthly and annual temperature and precipitation.

Month.	Sacramento.		Rocklin.		Auburn.	
	Temperature.	Precipitation.	Temperature.	Precipitation.	Temperature.	Precipitation.
	° F.	*Inches.*	° F.	*Inches.*	° F.	*Inches.*
January	46.4	3.82	46.4	4.16	45.6	5.88
February	50.5	2.65	49.8	3.14	48.1	4.85
March	54.8	2.94	54.9	2.90	51.7	5.14
April	59.3	2.28	60.4	2.98	56.5	3.21
May	64.2	.96	67.8	1.03	62.7	1.56
June	70.2	.17	79.0	.23	70.8	.43
July	73.6	.00	80.0	.03	76.8	.02
August	72.6	.00	78.2	.04	75.9	.02
September	69.5	.36	72.7	.18	71.0	.48
October	62.8	.90	63.6	1.14	64.6	1.87
November	53.5	2.15	53.9	2.29	55.0	3.93
December	47.0	4.14	47.9	3.77	47.0	6.07
Year	60.3	20.37	62.8	21.89	60.5	33.46

While the summer temperature is high, the relative humidity is usually low, increasing somewhat in the vicinity of the larger streams and other bodies of water. This greatly reduces the sensible temperature, rendering the heat of summer less oppressive and enervating. Humid periods are usually of short duration and infrequent occurrence.

Upon the north, east, and west sides the area is sheltered by high mountains, protecting the valley and foothills from the cold winter winds and storms of the north and east, and from the chilling sea breezes from the Pacific. During the summer the modified sea breeze from the Golden Gate usually passes up the Sacramento River and reaches the valley late in the afternoon. The wind movement is usually quite steady and prevailingly from south to southwest. During the summer hot, dry winds from the north, generally continuing from one to three or four days, are occasionally experienced. These are in striking contrast to the cooling sea breezes, and sometimes scorch the unprotected and unshaded tender vines and ripening fruit.

Throughout the summer the skies are clear. Fogs sometimes occur along the rivers during the night, but are soon dispelled by the morning's sun. The total number of clear days at Sacramento is unusually high. During the winter, however, rain clouds and fogs are of more frequent occurrence, the valley and the lower foothills being often more or less enshrouded in fog for periods of several days.

In general the climate is healthful and such as to favor horticultural and agricultural industries. During the winter a large proportion of the rainfall makes its way into the soil to be retained for the future needs of the plants, and there is but little loss from evaporation. The temperature favors the growing of a great variety of crops and fruits with little danger of injury from frosts. During the summer farming operations are rarely interrupted by unfavorable weather and the processes of fruit drying, harvesting, haying, etc., go on without danger of damage to the crop from unfavorable climatic conditions.

PHYSIOGRAPHY AND GEOLOGY.[a]

The elevation varies from 30 feet above sea level at Sacramento to about 2,100 feet at the opposite or northeastern corner of the area, and the slopes vary from the almost dead level of the valley plain to the precipitous and mountainous hillsides of the more rugged foothills. Drainage of the uplands is effected by a great number of streams and minor ravine channels. The most of these are intermittent in character, carrying water only during the rainy season, and cross the valley plain as insignificant meandering channels or rush their flood waters into the main drainage streams of the area. Of the latter, the American River, with its three forks threading their way among the hills of the eastern and northeastern portions of the area, is the most important. This river during the flood season carries a great quantity of water, and from the junction of the North and South forks near Folsom City traverses the southern portion of the area in a southwesterly direction and empties into the Sacramento River just after leaving the area. The Bear and Consumne rivers, also streams of considerable importance and subject to heavy floods, cross the northwestern and southeastern corners of the area, respectively. The main creeks, crossing the valley plain in a general southwesterly direction, flow into the Sacramento River, which skirts the western boundary of the area. During the summer period only the larger streams of the area, rising in the higher Sierras and foothills, carry any flow of importance.

[a] For much of the data concerning the topographic and geologic features of the area we are indebted to the United States Geological Survey. (See Geologic Atlas of the United States, Sacramento sheet.) Both these features are marked by great variety and complexity.

The valley plain covers a little more than the western half of the area surveyed, the towns of Lincoln, Roseville, Rocklin, and Folsom City nearly marking its boundary. The surface of the extreme western or lower portion is nearly level, but often covered by small mounds known as "hog wallows," which form a distinctive feature over much of the Sacramento and San Joaquin valley lands. These are most prominent along the western and that portion of the southwestern margin of the area lying on the north side of the American River. In the extreme southwestern portion small knoblike elevations give moderate physiographic relief to the landscape. The Bear and American rivers flow through wide, shallow channels but little below the surrounding country, which, when unprotected by artificial levees, is subject to inundation during high water. Valley oaks in considerable numbers frequently occur upon the undulations of the valley plain and in the vicinity of the river bottoms, while the stream courses are frequently fringed with oaks, cottonwoods, and willows. In the American and Bear river bottoms this growth of trees and brush is exceedingly dense. Aside from these features the plains are generally treeless.

Along the higher slopes of the valley plain the level character of the surface gives way to an undulating plain or a succession of rolling hills. The streams are here somewhat below the surrounding level and are often marked by lines of bluffs, as at Fairoaks, while the growth of oaks upon the undulations and ridges is increased.

In the belt of the lower foothills a distinctive physiographic feature consists of a series of barren, flat-topped volcanic ridges and knobs extending in a southwesterly direction from Auburn to the valley below. In the same vicinity, in contrast to these and followed by the main line of the Southern Pacific Railway, lies a trough or depression eroded from the coarse granitic rock. With the exception of the flat-topped ridges the lower hills are usually of rounded or domelike contour, with gentle slope. The streams have cut their way through rocky ravines and gorges, and in this natural condition the slopes are frequently covered with quite a heavy growth of the valley oak and liveoak, California buckeye, "digger" or grayleaf pine, coffeeberry, manzanita, species of ceanothus, and other characteristic trees and shrubs of the lower Sierra Nevada foothills.

With further increase in elevation, the slopes become steeper, the the ridges sharper and more rugged, while the streams flow through deep and narrow canyons. That of the North Fork of the American River near Auburn is about 1,000 feet deep, with precipitous forested slopes. In addition to vegetation previously mentioned, a rather dense growth of yellow pine is seen, which in the high and more rugged hills east of the American River gives way to a dense, thorny

growth of chaparral, consisting mainly of manzanita and chamisal, the latter being locally known as "greasewood."

The rocks of this area consist of those laid down under water and subsequently more or less consolidated, those ejected from volcanoes or intruded into adjacent rock masses from volcanic subterranean fissures, or rocks of both these classes or of uncertain origin so modified by heat or pressure as to assume entirely new characteristics.

The geology of the foothills is important in its relation to the soils formed by long-continued disintegration and decomposition of the rocks. The influence of the properties of the parent rocks is everywhere seen in the resulting soils. The older rock masses have, as a rule, been subjected to great heat and pressure and are folded, fractured, tilted, and crushed in a complex manner.

The prevailing rocks of the higher foothills are the amphibolites and diabases, the former being of schistose, or more or less slaty structure, and the latter frequently of dense, compact structure and fine granular texture. The prevailing color is green. These rocks, with minor bodies of sedimentary and intrusive masses of igneous rocks, occupy the eastern portion of the area. They are very rich in iron and weather into moderately heavy, red loams of fine or silty texture, frequently carrying a small percentage of flat, angular, or shaly fragments or gravel. The hills composed of these rocks usually have quite steep slopes and occur in ridges extending parallel with the main Sierra Nevada Range. The soil product of the diabase is usually of a deeper red color and somewhat heavier in texture than that derived from the amphibolite.

In the vicinity of Clipper Gap there is a considerable body of rock, consisting of limestones, slates, and dark sandstones, and in the resulting soil, which is nearly identical with that produced by the weathering schists and diabases, the properties of the slates and limestones predominate. As with the diabase and amphibolite, small quantities of flat, shaly gravel frequently occur in the soil, and rock outcrop is frequent and sometimes excessive. Many small lenticular bodies of this formation occur throughout the eastern portion of the area.

Extending southeastward across the area from a point about 1 mile southeast of Folsom City there are bodies of dark-colored slates. The main body averages about 1 mile in width, and there are two or three small and narrow parallel bodies to the eastward. This rock outcrops in sharp, jagged projections and ledges, and weathers very slowly into a light-gray or drab loam. The surface is usually barren of trees or shrubs, and the soil is shallow and unproductive.

In the high hills and brush-covered slopes in the vicinity of Pilot Hill, and to the southeast of Salmon Falls, occur bodies of a coarse,

granular rock, dark green or gray in color, classed as gabbrodiorite. This rock is extremely dense and resistant to the weather. It decomposes into a very heavy, compact clay loam of deep-red color, often resembling adobe and containing fine angular fragments. It frequently outcrops to such a degree as to render the land of no agricultural value, although when deep enough to support crops the soil is productive and valuable. Two or three small bodies of a modified form of this rock occur about 5 miles east of Sheridan, weathering into a productive, mellow, black sandy loam.

A few small, irregular bodies of serpentine rock are found near the eastern margin of the area surveyed. These are most prominent in the high, rugged hills in the vicinity of Flagstaff Hill and adjacent to the gabbrodiorite area near Salmon Falls. This formation is usually very dense, but is sometimes altered to white, slaty rock. It weathers very slowly, and the soil, which is very shallow or almost entirely wanting, is generally unproductive.

The greater portion of the lower foothills, lying between the towns of Auburn, Lincoln, Rocklin, and Folsom City, consists of a coarse granular, granitic rock—granodiorite—which is more easily eroded than those of the higher foothills. It disintegrates rapidly, but decomposes slowly, forming a red, gray, or dark colored coarse, granular sandy loam or loam containing usually an abundance of fine angular rock particles. The rock outcrops frequently as huge bowlders or masses, but the soil is very productive and largely devoted to the growing of deciduous fruits. A rough, rocky body of this formation devoted to grazing purposes occurs in the northeastern portion of the area.

Auriferous or gold-bearing gravels have accumulated along ancient and modern stream channels, and in recent times they have been greatly disturbed by processes of mining.

The flat-topped table-lands, to which reference has previously been made, in many cases cover the gold-bearing gravels and ancient stream channels, into which the volcanic muds and lavas were poured. Subsequent erosion of adjacent softer rock masses has left these bodies standing high above the surrounding country. The material consists of volcanic tufaceous breccia, in which are embedded fragments and bowlders of andesite rock.

Along the base of the foothills a series of white sands and clays are frequently exposed, especially in the vicinity of Lincoln and Rocklin and along the southern margin of the area to the southward from Folsom City. This deposit of sedimentary material was laid down under the waters of a shallow bay or inland sea at one time occupying the Sacramento Valley. This formation gives rise to sands, sandy loams, and more frequently to heavy dark-colored adobe.

The valley plain consists of alluvial material washed from the hills or carried into the ancient lake or sea bed in Pleistocene times. The presence of hardpan is general throughout this material, and strata of well-rounded gravel also frequently occur.

The river bottoms are usually marked by deep deposits of fine alluvial sands, silts, and clays.

SOILS.

The soils of the Sacramento area, like the physiographic, geologic, and general agricultural conditions, exhibit great variety and complexity. As a rule, they are productive and possess marked moisture-retaining properties. They are frequently highly colored and grade from one to another by imperceptible degrees. Sixteen types of soil were recognized, which, owing to natural physiographic and geological distinctions, fall with slight exception into two natural and well-defined groups, viz, the soils of the valley plain and the soils of the foothill belt.

In certain sections, particularly in the vicinity of Folsom City, the soils have been greatly disturbed by mining operations, producing unsightly beds and heaps of gravel, as well as deep and dangerous pits and trenches, in many cases rendering the land unfit for any agricultural use whatever. While the greater part of the lands so affected was originally suited only to grazing purposes, the extensive dredging operations are slowly encroaching upon the more valuable fruit and vineyard lands.

These barren and nearly worthless lands, as well as those marked by excessive rock outcrop or otherwise stony condition, are indicated upon the map by the proper symbols.

The soils of the valley plain occupy the western half of the area, which consists of nearly level plains and undulating slopes, stream bottoms, and flood plains. According to physiography, origin, and other natural features they are again divided into three groups, viz, those of the San Joaquin series, those of the Sacramento series, and miscellaneous soils. The soils of the San Joaquin series consist of the original alluvial material washed into the waters of the bay occupying the valley in Pleistocene times, and are generally underlain by red sandstone hardpan of secondary formation. The soils of the Sacramento series consist more of recent sediments derived from stream wash, while the miscellaneous soils are those not included in the two series mentioned.

Areas of different soils.

Soil.	Acres.	Per cent.	Soil.	Acres.	Per cent.
San Joaquin sandy loam	265,216	44.8	Fresno fine sand	6,656	1.1
Sierra clay loam	128,183	21.6	Fresno gravel	4,544	.8
Sierra sandy loam	64,448	10.9	San Joaquin red adobe	3,776	.6
San Joaquin fine sandy loam	30,208	5.2	Fresno red sand	1,920	.4
Sierra stony loam	30,080	5.2	Sheridan sandy loam	1,792	.3
Rough stony land	19,839	3.3	Fresno sand	1,408	.2
Salinas gray adobe	12,672	2.2	Riverwash	778	.1
Sierra loam	10,944	1.8	Total	591,488	
Sacramento silt loam	9,024	1.5			

SAN JOAQUIN SANDY LOAM.

The San Joaquin sandy loam consists of a loam or light-red sandy loam of medium to fine texture, but often carrying small quantities of coarser sharp fragments, the main body of the soil being fine, smooth, and somewhat silty in character. The average depth is about 3 feet, although subject to great variation. This material is underlain by a dense refractory red hardpan of very much the same texture as the overlying soil. The soil is sometimes separated from the hardpan by a stratum, usually but a few inches in thickness, of red sandy adobe of sticky character and dense structure, checking into small roughly cubical blocks. The underlying hardpan in most cases consists of several layers from a few inches to several feet in thickness, interstratified with red or light-colored sands, fine sediment, or gray or red sandy adobe.

In certan parts of the area, especially in the vicinity and north of Dry Creek, and also in the vicinity of the lower granitic foothills, coarse angular particles of rock, derived from disintegration of the granites, occur in both the soil and underlying hardpan. Heavy phases of the soil occur which grade into the adjacent loams.

In area the San Joaquin sandy loam is the most important soil type in the district surveyed. Except in the vicinity of the flood plains of the larger streams it covers nearly the entire western half of the area. The type is subject to considerable minor variation, but, aside from this characteristic, it occurs in great tracts of nearly uniform soil.

It extends from the lower level valley floor of the western margin of the area upward to the base of the foothills. The lower levels are frequently marked by the hog-wallow mounds, while the valley slopes in the vicinity of Fairoaks and Orangevale are quite rolling and hilly. The underlying arenaceous hardpan frequently outcrops along the margins of the ridges or is exposed at the surface near streams by erosion from flood waters. Gravel frequently occurs, especially in the vicinity of minor foothill streams and along the southern margin of the area. The lower levels of shallow soil are generally treeless, but along stream courses, where the hardpan is

frequently broken, and upon the upper valley slopes the oak trees and groves appear.

The San Joaquin sandy loam, although containing a considerable proportion of sand, is of compact structure, and when wet resembles adobe. It very readily puddles if worked while in a wet condition and bakes hard upon exposure. Upon the level or slightly sloping valley plains, where surface drainage is insufficient during heavy rains, the soil often becomes very soft and boggy, the impervious underlying hardpan allowing little or no percolation to lower depths. Upon the steeper slopes and undulating topography of the upper valley slopes drainage takes place more readily.

This soil is derived from the adjacent granitic, volcanic, and metamorphic rocks, the granitic material being the most evident. The material, from whatever sources, was washed from adjacent hills and deposited in the waters of the Pleistocene lake or bay. The underlying hardpan is believed to be a secondary formation taking place in more recent times, and caused by the precipitation of relatively insoluble iron salts mixed with particles of clay. The soil has undergone considerable modification in places by recent stream wash.

The most important natural feature of this soil from the point of view of the agriculturist is the underlying impervious hardpan. This does not soften upon application of water, and weathers and disintegrates very slowly. Alkali salts do not occur in this soil in injurious quantities.

The crops to which the San Joaquin sandy loam is adapted vary widely, according to depth at which the hardpan lies and location of the areas as regards topography, elevation, and local climatic conditions. Throughout the zone of shallow soil occurring upon the lower valley plain it is adapted only to grazing, grains, grain hay, or shallow-rooted crops, except along stream courses where the impervious hardpan strata are sometimes broken. Where the depth to hardpan is 3 feet or more it is, in general, adapted to grains, vines, berries, and citrus and deciduous fruits.

The lower valley plains are devoted generally to grazing or to extensive dry farming to wheat, oats, barley, and grain hay, with fair yields in favorable seasons. The upper valley margins and undulating slopes are cultivated to grains and hay, and when irrigated to vines, berries, peaches, cherries, plums, and various deciduous fruits, with profitable yields during favorable seasons. Olives and oranges are also grown to some extent in the vicinity of Fairoaks and Orangevale, and in areas of deep soil, and with proper irrigation they do well.

The long-continued growing of wheat in certain localities has caused a decrease in the productivity of this soil type, such areas now being sometimes devoted to oats, barley, rye, and grain hay.

A heavy phase of this soil of brighter red color and more loamy texture occurs along the upper valley slopes adjacent to the heavy red loams of the foothills. It is most prominent eastward from Sheridan, and southward from Folsom City. In topographic and drainage features, general origin, and character of underlying material it is identical with the typical soil. It departs from it only in the texture and properties of the soil, being finer, heavier, more sticky when wet, and somewhat more retentive of moisture. It has been considerably modified by recent wash from the adjacent hills. The areas of this phase are devoted mainly to grains and grazing, although grapes do well when properly irrigated and cultivated.

Another phase occurs in limited bodies on the lower valley, grading into adjoining bodies of heavy sediments and adobes. In general features and agricultural value it does not differ greatly from the adjoining soils, but it is of a darker color and a more compact structure than the typical San Joaquin sandy loam.

The following table gives the result of mechanical analyses of both soil and subsoil of the San Joaquin sandy loam:

Mechanical analyses of San Joaquin sandy loam.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
12012	1 mile NE. of Fair-oaks.	Medium sandy loam, 0 to 12 inches.	1.6	13.4	13.7	27.1	11.9	21.0	10.9
12009	6 miles NE. of Sacramento.	Medium sandy loam, 0 to 12 inches.	1.3	6.4	4.9	19.1	12.7	40.1	15.2
12001	2½ miles SE. of Walsh Station.	Red sandy loam, 0 to 12 inches.	2.3	7.5	4.5	14.9	15.3	37.4	18.0
12013	Subsoil of 12012	Red sandy loam, 12 to 48 inches.	.8	10.8	9.3	25.8	14.6	22.9	15.5
12010	Subsoil of 12009	Red clay loam, 12 to 18 inches.	.2	3.1	3.2	15.7	16.3	34.9	25.8

SAN JOAQUIN FINE SANDY LOAM.

The San Joaquin fine sandy loam consists of a buff to red fine sandy loam of smooth texture and with but little sharp material, rather sticky when wet and somewhat resembling silt loam, and when dry frequently exhibiting a moderately compact and close structure. In depth, it is subject to some variation, but is generally underlain at about 3 feet by a stratum of heavy light-brown or red loam or clay loam grading into red hardpan, of fine sandy or clayey texture. The

underlying material is similar to that of the San Joaquin sandy loam, except that the fine heavy loam generally takes the place of the sandy adobe, the hardpan being in itself generally of a somewhat finer texture and frequently less dense and continuous.

This soil type occurs mainly in the southwestern part of the area in one extensive and uniform body, lying southward from the American River. It occupies the upper bench of the ancient flood plain of that river, and extends in a southwesterly direction across the lower valley plain. The surface, aside from minor irregularities, is smooth, nearly level or gently sloping, and devoid of prominent topographic features. The type is in places separated from adjacent soils by slight terrace lines, and generally lies below the San Joaquin sandy loam. Near the river and more recent sedimentary soils, irregular gravelly bodies sometimes occur.

During wet periods the drainage conditions in this soil are like those of the San Joaquin sandy loam. It has, however, been subjected to modification by fine alluvial sediments from the flood waters of the American and possibly from the Sacramento River. Like the San Joaquin sandy loam, it possesses marked moisture-retaining properties, and is free from alkali salts. The soil when not too shallow is well adapted to stone fruits, grapes, and berries, as well as to dry farming to grain or hay. Wheat and other grains are extensively grown upon unirrigated tracts, the yields being generally good. Irrigated lands are intensively cultivated to grapes, the early and desirable Flame Tokay being in great demand, as well as to strawberries, bramble berries, and vegetables. Strawberry and table grape culture are popular and profitable industries upon this soil, which is generally more productive than the San Joaquin sandy loam.

The following table gives the result of mechanical analyses of this type of soil:

Mechanical analyses of San Joaquin fine sandy loam.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
12017	Walsh Station	Fine sandy loam, 0 to 12 inches.	0.5	4.5	5.3	39.2	21.3	18.8	9.9
12020	1½ miles S. of Perkins	Loam, 0 to 12 inches	1.8	5.0	2.9	12.6	15.6	38.2	23.7
12018	Subsoil of 12017	Fine sandy loam, 12 to 54 inches.	1.2	9.7	9.4	35.2	16.8	17.7	9.5
12021	Subsoil of 12020	Clay loam, 12 to 36 inches	.7	2.7	1.7	10.9	16.4	40.2	27.2

SAN JOAQUIN RED ADOBE.

The San Joaquin red adobe is a heavy red adobe, possessing the texture of a heavy loam or clay loam, usually about 3 feet deep, though varying greatly in depth, and underlain by the red sandy hardpan described in the preceding types of soil. The soil when wet is exceedingly tenacious and sticky, puddles readily, and bakes upon exposure to the sun. Small checks, extending to a depth of several inches, frequently appear, dividing the soil into cubical blocks. Small white angular rock fragments and fine, sharp gravel frequently occur in both soil and underlying hardpan.

The San Joaquin red adobe is not an important type, occurring only in a single area of a few square miles extent, and in one other smaller tract. These are found about 5 miles north of Pleasant Grove. The type occupies only the lower, nearly level slopes of the valley plain, and is unmarked by distinct topographic features. The surface is generally smooth, save for occasional mounds and minor irregularities. Except in the vicinity of the drainage channels, the surface is usually barren of trees or shrubs.

Owing to the dense structure of this soil, and to the impervious underlying hardpan, percolation and drainage take place slowly, while during the dry season it becomes very dry and compact.

Like the preceding soils of the San Joaquin series the San Joaquin red adobe is derived primarily from alluvial wash from the adjacent hills, composed of granites, diabase, amphibolite, and other rocks of volcanic and metamorphic origin. The present soil is, however, probably formed in part through the disintegration of underlying hardpan.

On account of its heavy texture and peculiar structure the soil is capable of receiving and storing large quantities of moisture. If the surface is prevented from baking, and the supply of underground moisture preserved by proper cultivation, a large proportion of the rainfall is rendered available for growing crops. The peculiar structural condition of this soil, while requiring careful treatment in order to prevent puddling and baking, becomes of great importance in the growing of shallow-rooted unirrigated crops.

The San Joaquin red adobe is devoted almost exclusively to dry farming grain and hay, with excellent yields in favorable seasons and with proper cultivation. Care should be taken to prevent the compacting or puddling of the surface, either by the tramping of stock or by farming operations. Thorough harrowing is of importance in counteracting the natural tendency of the soil toward this condition.

The results of the mechanical analyses of the fine earth of this type of soil are shown in the following table:

Mechanical analyses of San Joaquin red adobe.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
12024	3½ miles N. of Pleasant Grove.	Clay loam, 0 to 12 inches.	1.4	3.1	1.3	4.9	9.5	44.8	35.1
12025	Subsoil of 12024	Heavy clay loam, 12 to 60 inches.	1.1	5.1	3.6	11.7	9.0	35.4	33.6

FRESNO GRAVEL.

The Fresno gravel consists of all grades of gravel, cobbles, and occasional small bowlders, usually well rounded, mixed with coarse and fine river sands, and in places with heavier sediments. It generally extends to a depth of 6 feet and is underlain by river sands and hardpan. In the foothill belt, however, it is sometimes of less depth, and is underlain by the prevailing rock of the section in which it occurs.

The larger bodies of the type occur along the American River and in the vicinity of Fairoaks and Folsom City. Other smaller bodies occur throughout the foothills belt along ancient and modern stream channels, and in many instances these were too small to be shown upon the map.

The larger bodies of this soil in the vicinity of Fairoaks and Folsom City, occurring along the lower benches of the American River, are frequently separated from adjacent recent river sediments by slight terraces, while the bodies upon the north side of the river are separated from the adjacent and higher lying San Joaquin sandy loam by prominent bluffs. The finer material of the deposits usually covers the coarser gravel and often supports a considerale growth of willow, small cottonwood, and other trees and shrubs of the river bottoms. The smaller areas of the foothills occur on sloping hillsides or occupy ravines. Over much of the larger areas of the type the gravel has been greatly disturbed in recent times by dredging and other mining operations, which usually leave the surface a succession of great heaps of cobbles separated by deep pits and trenches.

In its original condition the Fresno gravel is well drained, but as a result of mining operations much of the water collects in the deep

pits, underlain by impervious hardpan or rock, during the rainy season.

All of the rocks of the Sierra Nevada Mountains and foothills are represented in these deposits, which have been spread about by rapidly moving and shifting currents of the streams during flood seasons. Some of the smaller outlying bodies are largely of colluvial or residual origin, the materials having been transported but short distances.

This type in its natural condition is adapted only to grazing, but where it has been subjected to dredging or other mining operations it is unfit for any agricultural use whatever.

FRESNO SAND.

The Fresno sand consists of a loose, incoherent sand of light color, generally 6 feet or more in depth, and underlain by fine loam, river gravel, and red arenaceous hardpan. It grades into the adjacent river gravel and recent river sediments.

This soil type is of little importance in the Sacramento area. It occurs only in a few irregular bodies adjacent to the American River, near Fairoaks, and also to a greater extent in the vicinity of Bear River. It occupies lower or intermediate terraces along the streams and has a level surface, sometimes gravelly, but devoid of rock outcrop or prominent physiographic features. Owing to its open texture and loose, porous structure, this soil is well drained, except in the vicinity of the Bear River, where it is sometimes subject to overflow.

The materials of the Fresno sand are derived from the varied rocks of the Sierra Nevada Mountains and foothills, particles of quartz, mica, and feldspar being the most prominent. This material has been deposited in its present position by the shifting currents and flood waters of the adjacent streams.

Owing to its texture and structure the Fresno sand is naturally free from alkali salts, while the underlying hardpan lies at such depth as to have little effect upon the growth of crops.

Types of soil of this class are less retentive of moisture than those possessing a heavier subsoil, but are well adapted to grapes and stone fruits requiring well-drained soils, which can be irrigated during the dry season. As there is practically no danger from puddling, cultivation can be practiced at almost any time, thus preventing the loss of much soil moisture after irrigation or rains.

In the vicinity of Fairoaks the Fresno sand is devoted largely to grapes and stone fruits, with excellent yields under effective systems of irrigation and cultivation.

The results of mechanical analyses of this soil type are shown in the following table:

Mechanical analyses of Fresno sand.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
12026	Fairoaks Bridge	Coarse sand, 0 to 12 inches.	1.4	15.4	16.3	32.8	14.2	12.4	7.2
11990	1 mile S. of Fairoaks.	Coarse sand, 0 to 12 inches.	4.0	17.9	15.6	31.7	10.9	11.4	8.3
12027	Subsoil of 12026	Coarse sand, 12 to 72 inches	1.2	12.8	15.8	37.7	13.5	13.8	5.2
11991	Subsoil of 11990	Brown coarse sand, 12 to 72 inches.	1.9	18.0	14.6	31.3	11.5	13.3	9.1

FRESNO FINE SAND.

The Fresno fine sand consists of about 3 feet of micaceous fine sand, from a light-yellow to brown or drab color, underlain by micaceous fine sandy loam, streaked with coarse or fine sands. The depth of soil and character of subsoil are, however, subject to considerable variation.

The main bodies of the type occur as rather narrow areas upon each side of the American River, extending from Mills Station to the western margin of the area. Smaller and less important bodies occur south of Sacramento, near Fairoaks, and also in the vicinity of Bear River. These several areas occupy the lower terraces and bottom lands of the lower courses of the larger streams of the area. The soil has a level surface, is sometimes gravelly, and frequently separated from adjacent soil types by minor terrace lines, and in its original condition is usually covered by a dense growth of willows and brush.

Natural drainage is favored by the open porous texture of the soil and subsoil. Owing to the position of the lower lying bodies, however, the soil in the vicinity of Sacramento and along Bear River is somewhat subject to overflow and seepage waters during the winter and spring floods. Protection by levees is necessary, and artificial drainage is sometimes required during wet periods.

The Fresno fine sand originates with the fine micaceous material derived from the granitic, diabasic, and fine-textured rocks of the foothills and mountains, deposited over the flood plains from the slack flood waters of the main streams.

The micaceous material is a very prominent constituent, imparting a smooth, greasy feel to the soil. Owing to the rapidity of capillary

movement and the more or less complete saturation of the subsoil of the lower lying bodies, alkali salts have here accumulated in the surface of the soil to a slight extent, it is believed, through the concentration of minute quantities occurring in the sediments. The alkali is not found in sufficient quantities to interfere with plant growth, and owing to soil structure, frequent natural flooding, and the penetration of the loose, porous soils by moderately heavy rainfalls damage from this source is not likely to occur.

The depth of the soil in this type and the usual moist condition of the subsoil allows alfalfa to be grown upon the lower bodies with little or no irrigation, provided the crop be protected from overflow and seepage from streams during long-continued flood periods. The soil is easily cultivated and excellently adapted to berries, vegetables, pears, stone fruits, hops, and asparagus. In point of variety and yield of intensively cultivated crops, this soil is among the most important of the area. Hops, asparagus, vines, fruits, and vegetables are the important crops grown. Alfalfa is also grown to a slight extent in connection with the dairying industry.

The following table shows the results of mechanical analyses of this type of soil:

Mechanical analyses of Fresno fine sand.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
12028	½ mile N. of Man Love.	Yellow fine sand, 0 to 36 inches.	0.1	1.1	1.3	26.3	32.0	32.6	6.5
11992	1 mile NE. of Sacramento.	Heavy fine sand, 0 to 12 inches.	Tr.	1.3	4.1	28.7	28.5	28.2	8.8
12029	Subsoil of 12028	Fine sandy loam, 36 to 72 inches.	.2	3.1	2.1	13.8	22.3	47.7	10.5
11993	Subsoil of 11992	Fine sandy loam, 12 to 72 inches.	.1	1.1	1.9	22.5	22.0	38.9	12.8

SACRAMENTO SILT LOAM.

The Sacramento silt loam, another important type of the area, consists of about 3 feet of moderately heavy silt loam, underlain by a brown or dark-colored clay loam, or by lighter sediments. The soil is of a very fine, smooth texture, somewhat micaceous, very sticky, and apt to puddle when wet, but of a loose, friable structure when in proper condition, and of impalpable and powdery texture when thoroughly dry. The surface foot is of a light-brown color, sometimes grading to black at about 18 inches. As in the Fresno fine sand, the

depth of soil and the character of the underlying material are subject to great variation.

The main bodies of this soil type occur upon the north side of the American River, near the city of Sacramento, and also adjacent to the Bear River. Smaller irregular bodies occur in the vicinity of the American Basin and throughout the lower valley plain. The larger areas occupy portions of the lower river bottom lands and are subject to frequent overflow during flood periods. The smaller bodies occur as slight depressions in the valley plain or as irregular streaks and patches adjacent to or near minor stream channels crossing the lower valley slopes. The surface is level, except for occasional minor terrace lines or irregularities caused by unequal deposition or erosion, is without gravel, and in the case of large bodies adjacent to streams is often covered with a dense growth of cottonwood, willow, and brush.

The areas of Sacramento silt loam frequently lie below the level of the adjacent stream beds, and because of this and the rather close and dense structure of the subsoil, especially of the heavier phases, they are in many places wet and poorly drained during and following flood periods. When underlain by lighter sediments, however, the natural condition is improved, and the soil drains rapidly after the floods subside. The protection of these lands by levees, owing to the character of the floods and to the constant filling of the stream beds by " slickens " or mining débris, is often very difficult and costly. When overflow is successfully prevented the filling of the soil by seepage waters from the higher stream beds often takes place. Notwithstanding these unfavorable conditions, the soil becomes available for summer and fall crops.

The origin of the material composing this type is similar to that of the preceding alluvial soils, it being merely of a finer texture, deposited along stream flood plains and in depressions by slack silt-laden waters. As in the Fresno fine sand, small amounts of the common alkali salts sometimes occur near the surface, but this condition has not assumed serious proportions and is unlikely to do so.

Alfalfa, fruits, and berries requiring deep and moderately heavy soil do well on this type of soil when protected from floods. The soil is especially well adapted to beans and other vegetables, sugar beets, potatoes, and, when underlain by the lighter subsoils, to hops. Of these crops, beans and truck are grown upon the heavier phases of the soil, while the smaller bodies occurring upon the valley plain are generally devoted to grazing and to the production of grains. In the vicinity of Bear River small fields of alfalfa are seen, and upon the north side of this river, where the soil is generally underlain by fine sands and fine sandy loams, hops are extensively grown, the yields being heavy and of excellent quality.

The results of mechanical analyses of typical samples of both soil and subsoil of the Sacramento silt loam are given in the following table:

Mechanical analyses of Sacramento silt loam.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
11994	3 miles NE. of Sacramento.	Brown silty loam, 0 to 12 inches.	0.0	0.2	0.2	4.7	13.9	64.7	16.2
12030	1½ miles N. of Sacramento.	Yellow silty loam, 0 to 12 inches.	.0	.2	.6	2.5	5.4	72.0	19.0
12031	Subsoil of 12030..	Heavy silty loam, 12 to 72 inches.	.0	.4	.2	2.8	10.2	66.0	20.0
11995	Subsoil of 11994..	Brown clay loam, 12 to 36 inches.	Tr.	2.3	2.5	6.8	8.0	45.3	34.8

RIVERWASH.

The Riverwash consists of coarse, loose materials, varying from sand to cobbles and small bowlders, all the particles being generally well rounded. In this area the coarse sands and fine gravel predominate.

This type is found chiefly in the vicinity of Bear River and occurs as small narrow bodies following the courses of the streams in the foothills and plains regions. It occupies the beds and lower terraces of these streams and is subject to overflow during flood periods.

The material represents the coarser grades of mountain waste, augmented by mining débris, and is deposited from rapidly moving waters of streams in flood.

Owing to position and to texture it is unsuited to the production of any crop.

FRESNO RED SAND.

The Fresno red sand, to a depth of about 18 inches, is a coarse gray to dark-brown sand or sandy loam. This material is underlain by a red sandy loam, also of coarse texture, grading into red sandy adobe and red sandy hardpan. The soil in its natural condition is rather compact, but upon cultivation assumes a loose, porous structure.

This type occurs only in a few small bodies of irregular shape in the vicinity of Fairoaks and Orangevale. It occupies the summits of the higher ridges and undulations of the upper valley margins, and is unmarked by rock outcrop or gravel areas. Owing to the sloping surface, elevated position, and open porous structure, the soil is naturally well drained.

The origin of this soil is less obvious than that of the alluvial soils previously described. It was probably formed from materials derived from the adjacent granitic rocks, intermingled with the wash from the diabase, amphibolite, and volcanic rocks found in the region. The materials were probably distributed by ancient streams or by the waters of the ancient Pleistocene lake or bay.

While the soil is of open, porous structure and well drained, the heavy subsoil is capable of absorbing and retaining large amounts of moisture. The surface upon cultivation breaks into a loose mulch, greatly retarding evaporation. The underlying hardpan is generally found at such a depth as not to interfere greatly with the growth of trees when well irrigated.

The Fresno red sand is best adapted to the growing of citrus and stone fruits, vines, and early truck crops under irrigation. Although it is quite limited in extent it is one of the most important fruit-producing soils of the Sacramento area, and generally outranks the surrounding San Joaquin sandy loam. Peaches, plums, cherries, apricots, olives, oranges, and other fruits are grown with success.

The results of mechanical analyses of soil and subsoil of the type are shown in the following table:

Mechanical analyses of Fresno red sand.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
11999	Orangevale	Gray coarse sand, 0 to 16 inches.	5.4	34.8	15.7	16.9	6.1	10.9	9.7
11997	2 miles W. of Orangevale.	Dark coarse sandy loam, 0 to 18 inches.	2.3	16.7	11.5	26.7	11.5	18.4	12.2
12000	Subsoil of 11999	Red sandy loam, 16 to 36 inches.	4.2	34.3	12.5	15.7	6.1	14.1	12.9
11998	Subsoil of 11997	Red sticky sandy loam, 18 to 36 inches.	4.5	31.2	11.1	12.3	4.6	9.5	26.7

SALINAS GRAY ADOBE.

The Salinas gray adobe, like many other adobe soils, is subject to many variations. As typically developed it is a dark-gray to nearly black heavy adobe, with the texture of a clay loam. It often carries coarse, white, angular rock particles, and sometimes considerable fine to rather coarse sand. It ranges in depth from 4 to 6 feet, and is underlain by sand and clay beds, or volcanic mud flows.

The type occurs as irregular bodies along the upper valley margins and base of the foothills, extending downward into the valley plain.

A phase of the type also occurs over a portion of the lower valley plain, and will be described separately. The most typical areas occur mainly south and east of Lincoln, in the vicinity of Rocklin, and in the southern part of the area surveyed. They occupy the slopes of rolling, domelike ridges, or flat-topped table-lands, extending downward and covering the trough of minor drainage depressions and sinks. The surface of the higher slopes is sometimes broken by outcrops of the underlying rock. Trees and shrubs of the valley margins sometimes appear, but only as scattered specimens. The higher slopes are sometimes marked by occasional springs and marshy or boggy spots. The soil is extremely sticky when wet, and is capable of absorbing large quantities of water. The soil of both the upper and lower slopes is likely to become soft and boggy during rainy periods. Many of these small wet patches might be greatly improved by artificial drainage.

The exact origin of this adobe soil is not well understood; in fact, the same soil may apparently be duplicated under a variety of dissimilar conditions of mineralogical origin and mode of formation. Both residual and alluvial phases of this soil occur with but little apparent difference in texture, structure, or agricultural value. Typically, however, the Salinas gray adobe of the Sacramento area results from the weathering and breaking down of interstratified beds of clay, sand, and volcanic muds laid down under Pleistocene waters. This material has since been distributed and modified by stream wash, being subjected at the same time to a more complete decomposition and changed by the addition of organic matter.

Owing to heavy texture and peculiar structure, this soil is readily puddled, baking upon exposure, and checking into large, roughly hexagonal blocks, or sometimes into small cubical fragments. When wet, cultivation is very difficult and attended with the risk of rendering the soil still more refractory. If intelligently handled, however, both the soil and subsoil, by reason of their moisture-retaining properties, become an excellent medium for the maintenance of the moisture supply.

This soil is generally unirrigated, and is adapted to grazing and to the raising of grains and hay. With irrigation and drainage, good yields of corn, root crops, sorghum, and other forage crops should be obtained. The type is used chiefly as pasture for sheep and other stock, or dry farmed to grains and hay, the yields being good under favorable conditions.

The valley phase of the Salinas gray adobe consists of about 3 feet of heavy, compact, silty to clayey adobe, gray to black in color, underlain by a sandy adobe or sandy loam, the latter occasionally containing a large amount of marl or lime. The underlying material varies greatly and sometimes grades into the red sandy hardpan. This

phase occurs as numerous irregular bodies throughout the valley plain, generally occupying local drainage depressions or sinks. In drainage features it is similar to the upland areas of this type.

Unlike the typical Salinas gray adobe, the phase is of alluvial or colluvial origin, the material being washed by flood waters from the uplands adobe, augmented by fine sediments washed from the soils of the plains.

In mineral and chemical properties and adaptation to crops it is similar to the upland soil of this area. The following table shows the results of mechanical analyses of both soil and subsoil of the Salinas gray adobe:

Mechanical analyses of Salinas gray adobe.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
12002	8 miles S. of White Rock.	Gray clay loam, 0 to 12 inches.	0.8	2.8	3.0	11.5	10.2	42.4	29.2
12004	3 miles N. of Sacramento.	Gray heavy clay, 0 to 12 inches.	.3	2.4	2.1	5.5	6.5	40.6	42.4
12003	Subsoil of 12002	Clay loam, 12 to 72 inches.	.6	2.3	2.1	8.3	10.3	37.8	38.6
12005	Subsoil of 12004	Black heavy clay, 12 to 36 inches.	.3	2.7	2.2	5.3	6.0	31.1	52.1

ROUGH STONY LAND.

The Rough stony land consists of areas possessing a rather shallow soil, and where the bed rock outcrops excessively. The soil varies in color from a gray or drab-colored loam to a dark-red heavy loam.

A large body of the type, nearly 1 mile in width, begins about 1 mile southeast of Folsom City and extends in a southeasterly direction across the area. Portions of the type occupy high rolling hills and precipitous slopes of the higher foothills, some being extremely rough and almost inaccessible, and covered with angular bowlders, rock outcrop, and a dense and nearly impenetrable growth of chaparral or brush. The surface of large areas occurring upon the rolling and generally treeless ridges of the lower foothills is marked by frequent outcrop, usually appearing as peculiar flat, sharp, jagged projections following the trend of the ridges. Here the soil ranges from 6 inches to 2 feet in depth, seldom becoming deeper except in rifts in the almost vertically tilted rock.

The soil of the Rough stony land is residual in origin. Owing to its general shallowness and the prevalence of outcropping ledges cul-

tivation is well-nigh impossible, and except for the growth of native vegetation available for grazing purposes the type has no agricultural value.

The following table gives the results of mechanical analyses of the fine earth of this soil type:

Mechanical analyses of Rough stony land.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
12046	7 miles W. of White Rock.	Gray loam, 0 to 12 inches.	14.4	21.9	6.4	11.8	5.1	18.2	22.2
12047	Subsoil of 12046.....	Gray loam, 12 to 24 inches.	7.8	14.6	6.3	14.7	9.7	25.1	21.8

SIERRA STONY LOAM.

The Sierra stony loam consists of a heavy loam of fine, smooth texture, varying in color from light red to dark brown or nearly black. It ranges in depth from 6 to 30 inches, the average being about 18 inches, and is underlain by volcanic gravels, muds, and breccias. The surface is generally gravelly and strewn with rounded cobbles and bowlders of volcanic andesite rock.

This type occurs in one large and many small bodies of very irregular outline, in the central part of the area, in the vicinity of Lincoln, Auburn, Newcastle, Rocklin, Roseville, and Folsom City. It occupies the summits of the flat-topped volcanic ridges and knobs which form a characteristic physiographic feature of the central lower foothill belt. The surface is nearly level or moderately sloping, thickly strewn with bowlders, and generally treeless, although sometimes a sparse growth of gray-leaf pine and other trees and shrubs of the foothills occurs.

Although occupying an elevated position, this type of soil is somewhat poorly drained, owing to the heavy texture of the soil and the usual flat, level character of the surface, and the fact that it is underlain at shallow depths by impervious material. The soil dries out slowly after heavy rains, and springs often appear along the foot of the slopes and the margins of the soil areas. Like all the soils of the Sierra series, it is residual in origin, being formed by the slow disintegration and decomposition of andesitic bowlders and the underlying volcanic muds and breccias.

Owing to the shallowness of the soil and the stony character of the surface, the Sierra stony loam is devoted only to grazing, for which it is of considerable value during the winter and spring months.

The following table shows the results of mechanical analyses of the fine earth of the soil and subsoil of this type:

Mechanical analyses of Sierra stony loam.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
12035	½ mile W. of Lincoln	Dark-red loam, 0 to 15 inches.	2.9	10.5	5.4	15.0	10.5	34.2	21.5
12032	1½ miles E. of Roseville.	Brown loam, 0 to 15 inches	8.1	9.3	5.0	14.7	10.8	29.5	21.9
12034	1½ miles E. of Roseville.	Red heavy loam, 0 to 12 inches.	4.8	8.2	4.4	14.0	11.2	33.2	24.0
12033	Subsoil of 12032	Red stony loam, 15 to 21 inches.	9.6	20.1	8.6	17.9	3.7	19.5	20.5

SIERRA SANDY LOAM.

The Sierra sandy loam is subject to considerable variation in texture, color, and depth. The typical soil, to a depth of from 3 to 6 feet, consists of a coarse sandy loam of a light-red to gray color, containing an abundance of fine, angular, light-colored rock fragments or fine gravel. While the soil is sometimes very shallow, it is often more than 6 feet in depth. It is underlain by a narrow zone of red plastic, sandy adobe similar to the overlying soil, but of somewhat heavier texture and grading into granitic rock.

It is one of the most extensive and important soil types of the foothills region. The main body of the type is found in the central northeastern part of the area, lying between the towns of Lincoln, Auburn, and Folsom City. It usually covers the rolling, domelike slopes of the lower foothills. While some of these slopes are steep, they are seldom so much so as to prevent cultivation. The underlying rock frequently outcrops as ledges or huge masses of bowlders, well rounded by erosion. The slopes are covered by the usual shrubs and trees of the lower foothills.

Occasionally the rock outcrop predominates and the slopes become so precipitous as to render the lands of but little agricultural value, this condition being most noticeable in the vicinity of the gorge of the North Fork of the American River, and in an area occurring in the extreme northeastern part of the survey.

The Sierra sandy loam is generally well drained; some minor depressions, springs, and swampy spots, however, would be greatly benefited by artificial drainage. The soil is the direct result of the disintegration and breaking down in place of the outcropping and underlying granodiorite rock. While chipping and breaking down into fragments rapidly, the rock is only slowly decomposed, the resulting soil being due rather to physical than to chemical agencies.

Like the other soils of the Sierra series, the Sierra sandy loam does not contain injurious quantities of alkali salts. It is splendidly adapted to the growing of berries, vines, citrus and deciduous fruits, suited to the climatic conditions of this area. Peaches, plums, cherries, apricots, pears, grapes, figs, oranges, strawberries, bramble berries, and other staple fruits of the foothill belt are grown in great quantities.

The dark phase of the Sierra sandy loam is of a finer texture, lacking much of the coarse, angular material of the typical soil, and grading from dark gray to nearly black in color. This phase occurs along the eastern margin of the main body of the type and adjacent to the neighboring amphibolite and diabase rocks.

It differs from the typical soil mainly in that it has a darker color, finer texture, poorer drainage, and in carrying a greater proportion of hornblende and diorite mica particles.

The following table shows the results of mechanical analyses of the fine earth of both soil and subsoil of this type:

Mechanical analyses of Sierra sandy loam.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
12036	1 mile W. of Roseville.	Coarse sandy loam, 0 to 12 inches.	14.6	26.8	11.6	18.4	6.2	12.9	8.9
12039	1 mile S. of Newcastle.	Coarse sandy loam, 0 to 12 inches.	11.4	20.3	8.5	16.8	8.6	17.2	16.7
12037	Subsoil of 12036	Coarse sandy loam, 12 to 36 inches.	13.2	25.5	11.9	18.3	7.2	12.5	11.1
12040	Subsoil of 12039	Coarse sticky sandy loam, 12 to 72 inches.	10.1	18.4	7.4	13.6	6.8	15.9	27.3

SHERIDAN SANDY LOAM.

The Sheridan sandy loam is somewhat similar to the dark phase of the Sierra sandy loam. It consists of a black friable sandy loam

of medium texture. In places the soil is very shallow, but in other cases it greatly exceeds the average depth, which is about 3 feet. It is underlain by granite rocks.

This is relatively an unimportant type, occurring in only two small areas in the extreme northern part of the survey. It occupies the lower valley slopes of the foothills adjacent to the upper undulating valley margins, and extends into the local drainage depressions. The native vegetation consists of the usual shrubs and trees of the lower foothills. Outcropping masses of rock and bowlders frequently occur. Natural drainage is facilitated by the open friable character of the soil. Its topographic position, however, is sometimes less favorable, springs and poorly drained spots occurring along the lower slopes and in depressions.

The Sheridan sandy loam is of residual or colluvial origin, resulting from the weathering of dark-colored, fine-textured phases of gabbrodiorite and granodiorite rock. The material in the lower lying areas has been washed from the slopes and subsequently modified by alluvial material. A characteristic feature of this rock is the large proportion of black hornblende and biotite mica which it bears, the plates and particles of which give rise to the black color of the soil.

When well drained the Sheridan sandy loam is adapted to grains, hay, forage crops, and fruit. The first three are chiefly grown at present. The areas also furnish good pasturage.

In the vicinity of drainage depressions, alluvial phases of this soil occur. Here the soil is often 6 feet or more in depth and is frequently underlain by stream gravels. In all important features it is similar to the typical upland soil, except that by virtue of its greater depth it is frequently better adapted to agricultural purposes.

The results of mechanical analyses of the fine earth of both soil and subsoil of the Sheridan sandy loam are shown in the following table:

Mechanical analyses of Sheridan sandy loam.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
12045	5 miles E. of Sheridan.	Sandy loam, 0 to 18 inches.	1.4	6.8	7.7	32.4	22.5	18.7	10.3
12043	7 miles N. of Lincoln.	Coarse sandy loam, 0 to 12 inches.	3.7	15.1	10.4	29.7	14.9	15.0	11.2
12044	Subsoil of 12043	Coarse sandy loam, 12 to 36 inches.	4.4	17.8	10.3	28.2	12.9	14.5	11.7

SIERRA CLAY LOAM.

The Sierra clay loam is a heavy loam of smooth, silty texture, often gravelly, and varying from a light-red to a very deep-red color. In depth of soil it varies greatly, but the average depth is probably about 3 feet. When dry the soil is moderately friable, and when wet becomes sticky and tenacious. It is underlain by bed rock. The gravel usually consists of flat shaly chips and rock fragments.

The Sierra clay loam is the prevailing soil type of the foothill region, and in extent of area devoted to important horticultural and agricultural interests ranks next to the Sierra sandy loam. It is extensively developed in the Sacramento area, where it stretches in one broad unbroken body along the eastern boundary, from the southern to the northern limits of the survey. At the north the same broad belt reaches more than half way across the area.

It occupies the slopes of the higher foothills, and in the northern part of the area surveyed and southward from Folsom City extends downward to the valley margin. In eroded districts, particularly in the vicinity of canyons and gorges, the surface is sometimes very steep, but moderate and more easily accessible slopes predominate. In general, the ridges are higher and the slopes steeper than those of the main body of the Sierra sandy loam. Bowlders and outcropping ledges and rock masses of subangular and only partially eroded contour frequently occur. The outcropping ledges become excessive over much of the southeastern portion of the area surveyed. In this section the slopes, owing largely to the shallow soil, are treeless and unproductive. Upon the deeper areas the vegetation of the intermediate and higher foothills prevails, consisting mainly of oaks, gray-leaf and yellow pines, and shrubs, consisting of ceanothus and coffeeberry.

The Sierra clay loam results from the weathering in place of the outcropping and underlying amphibolite, diabase, and limestone rock. The processes of rock decomposition are here generally well advanced, although the rocks are not weathered deeply. The diabase usually gives rise to a somewhat heavier soil of deeper red color than that derived from the amphibolite and limestone.

The soil is somewhat tenacious and readily absorbs water. Owing to topographic position, surface drainage is nevertheless rapid and general drainage conditions are good. Under proper cultivation the moisture-retaining properties are generally superior to those of the Sierra sandy loam. The soil, however, is not so easily cultivated, is often shallow, and possesses a slight tendency toward puddling when wet.

The deeper areas of this type of soil are well adapted to the production of grains, hay, grapes, and the usual deciduous fruits of the

foothill district. Olives do well upon the steeper slopes. The shallower and rocky areas are best adapted to grains, hay, and grazing. Some of the deeper areas, under careful and thorough cultivation, are capable of producing in favorable seasons fair crops of table and wine grapes with little or no irrigation. The yields are usually equal or, in some cases, superior to those of the Sierra sandy loam. Owing to soil texture and to topographic position many of the fruits reach maturity somewhat later than those of the lower granitic foothills.

The following table gives the results of mechanical analyses of the fine earth of typical samples of both soil and subsoil of the Sierra clay loam:

Mechanical analyses of Sierra clay loam.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
12048	6 miles NW. of Auburn.	Red silty loam, 0 to 12 inches.	3.0	6.7	3.1	8.0	7.8	47.8	23.3
12050	4½ miles NW. of Auburn.	Red heavy loam, 0 to 12 inches.	2.4	5.6	3.6	10.1	8.4	44.4	25.0
12049	Subsoil of 12048	Dark red loam, 12 to 40 inches.	3.6	8.9	3.8	9.6	6.9	48.0	19.1
12051	Subsoil of 12050	Red clay loam, 12 to 36 inches.	3.4	8.0	4.3	10.7	5.8	38.2	29.6

SIERRA LOAM.

The Sierra loam is a heavy, dark-red loam of close structure, checking occasionally upon exposure, and very sticky when wet, with a tendency to puddle if cultivated in that condition. It ranges in depth from a few inches to several feet. The subsoil often resembles residual red adobe, and is underlain by the bed rock. Small white angular or subangular rock particles often occur in both the soil and subsoil.

The Sierra loam is a relatively unimportant soil type, occurring in limited areas in the vicinity of Pilot Hill and Salmon Falls. While some of the slopes occupied are only gently rolling, the prevailing topography is rugged, some of the slopes being very steep and covered with rough, irregular bowlders, outcropping ledges, and with the chaparral growth of the more rugged and mountainous foothills.

Owing to its heavy texture and structure, this type is naturally somewhat slowly drained, but this unfavorable condition is usually

offset by the elevation and topographic features, which facilitate rapid surface drainage.

The soil originates from the disintegration and decomposition of the underlying and outcropping gabbrodiorite rock, which is very massive and breaks down under the influence of weathering slowly.

Owing to the frequent rock outcrop and shallow soil, large portions of the type are at best only suited to grazing. The deeper and smoother areas, however, when cleared of brush give good yields of hay and grain, and it is possible that successful grape and fruit culture might be carried on in a few of the more favored localities.

The results of mechanical analyses of the fine earth of both soil and subsoil of this type are shown in the following table:

Mechanical analyses of Sierra loam.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
12054	3 miles NE. of Clarksville.	Heavy loam, 0 to 12 inches.	7.5	14.6	7.6	16.8	9.6	23.5	20.1
12052	10 miles NE. of Folsom City.	Heavy loam, 0 to 15 inches.	4.5	12.3	6.5	15.5	10.9	27.3	22.2
12055	Subsoil of 12054	Loam, 12 to 36 inches	7.6	20.4	8.0	16.3	8.6	17.9	21.2
12053	Subsoil of 12052	Clay loam, 15 to 66 inches.	4.3	10.3	5.3	14.4	8.2	30.3	27.1

HARDPAN.

Except in areas of alluvial deposits near the larger streams, the occurrence of hardpan is general throughout the valley portion of the area. It is particularly well developed in those districts having the "hog wallow" mounds, which appear as a distinctive feature along the western margin of the survey. These mounds, however, are less prominent than those occurring in portions of the San Joaquin Valley, where hardpan is also found.[a]

The hardpan of the Sacramento area usually consists of red sandstone or clay-sandstone strata, from a few inches to a few feet in thickness, interstratified with layers of light-colored, compact or unconsolidated sand, gravel, partially disintegrated sandstone, or sandy or clayey adobes. The whole indurated system may extend to a depth of many feet, and is frequently exposed in cuts and bluffs, as along the American River at Fairoaks. It is usually encountered at

[a] See Soil Survey around Fresno, Cal. Field Operations, Bureau of Soils, 1900.

a depth of from 2 to 4 feet, and upon the lower valley bottoms often lies much nearer the surface over extensive tracts, or is frequently exposed by superficial erosion.

In the rolling valley slopes in the vicinity of the foothills it commonly lies deeper and is less continuous in character, and frequently outcrops as ledges along hillsides and ridges.

In the southwestern part of the area and south of the American River the strata seem to be generally less thick and dense. The material here and also in the vicinity of Fairoaks varies from the dense red sandstone of medium texture to a compact, white chalky material. The latter seems to be merely a very fine sediment compacted by pressure and having very little, if any, cementing material. The red material, however, is much more refractory and weathers very slowly upon exposure, the cementing material being principally hydrous silicates of iron. The hardpan strata are frequently separated from the overlying soil by a narrow zone of compact red adobe, frequently containing considerable sand or fine angular gravel.

An impervious hardpan of the character found in this area exerts a marked influence upon agriculture, and may render otherwise productive and favorably situated soils nearly or entirely useless for agricultural purposes. It limits the feeding ground of plants and confines the percolation of the rainfall to that part of the soil lying above the impervious stratum, with the result that the moisture finds its way to the surface to be lost by evaporation, and it cuts off the supply of moisture from the deeper soil.

Owing to the close approach to the surface of this material, large tracts of land lying north of Sacramento, on the opposite side of the American River, are used only for grazing purposes. Over the greater portion of the valley, however, grain and shallow-rooted crops may be profitably grown. Upon the higher rolling lands trees and vines are successfully grown, while southeast of Sacramento the culture of strawberries, grapes, and small fruits has become an established and profitable industry.

Tracts in which the material prevails nearer the surface than $2\frac{1}{2}$ or 3 feet should be cultivated to shallow-rooted crops that either mature quickly before the advent of the hot, dry months, or that may be supplied with moisture by irrigation. In extreme cases blasting is sometimes restored to in loosening and breaking up the hardpan.

RECLAMATION OF SWAMP LANDS.

Large unbroken tracts of swamp and overflow land extend throughout the lower Sacramento and San Joaquin valleys. Very little typical swamp land occurs, however, within the limits of the area surveyed, and this consists of small irregular depressions, of insufficient drainage and subject to overflow, found chiefly in the lower

American River and Bear River bottoms. Small isolated tracts also occur in the lower foothills, caused frequently by obstruction of natural drainage through mining operations. An area of several hundred acres of overflowed land, known as the American Basin, lies about 4 miles north of Sacramento, along the Sacramento River. Much of this land is available for grazing purposes during the dry summer season.

Small swampy bodies upon the higher slopes and levels may be profitably reclaimed by a system of open or tile drains. The reclamation of the more extensive overflowed lands adjacent to the river courses can be effected only by constructing an elaborate and expensive system of levees and drainage channels.

WATER SUPPLY FOR IRRIGATION.

In the early days of agriculture in the Sacramento area irrigation was thought to be unnecessary, but when the growing of fruit began to assume importance along the foothills and in the river bottoms, experiments in a few orchards showed that the trees did much better and gave larger yields where water was used, and from this beginning the practice has spread, until irrigation, at least in fruit growing, has come to be regarded as a necessity.

The water used for irrigation purposes is derived both from the streams and from an underground supply. Of the streams, the American River furnishes the main supply, followed by the Bear and Yuba rivers. North Fork Ditch, extending from the North Fork of the American River some distance below Auburn, supplies much of the foothill fruit land lying north of Folsom City, and large tracts of the upper valley slopes in the vicinity of Orangevale and Fairoaks. The Natoma Ditch, tapping the same river, supplies large tracts of vineyard lands upon the south side of the river in the vicinity of Natoma. The main supply covering the foothill belt southward from the vicinity of Auburn is drawn from the Bear and Yuba rivers outside the limits of the area surveyed, and brought into the area through a single large canal entering at the northeastern corner. In addition to these large canals, there are a number of minor ditches deriving water from various streams and used as a supplementary supply. Many of the smaller and some of the larger canals were formerly used solely, and are still used partially, in mining operations.

In the vicinity of Fairoaks, Orangevale, and over part of the foothills region the water is distributed in underground pipes of various sizes, hydrants being placed upon the summits of knolls and ridges, from which the water is distributed in furrows. By this means all loss from seepage is prevented, and the canal and pipe lines being subject to rapid fall, the water is secured under pressure and brought

to the higher elevations. This system, however, when it becomes inadequate to supply the demands, is enlarged with difficulty. Serious loss has already been experienced from an inadequate water supply, especially in the vicinity of Fairoaks, and a system with increased capacity is much needed at this point.

For the most part, with economical use and proper cultivation, the water supply of the foothill belt is sufficient for the present needs, but the further extension of irrigation to large tracts of unimproved land of the lower foothills and upper valley slopes adapted to fruit culture will necessitate an enlargement of all these systems. The streams forming the source of supply carry during flood seasons enormous quantities of water, but during the dry season the supply is limited. The supply can be greatly increased by the construction of additional canals, supplemented by reservoirs. In the Sierra foothills such work is attended with great cost, and further development of the systems will take place rather slowly and only to supply real and immediate needs.

Lying south of the American River and extending southwest from Natoma to the limits of the area, is an important belt devoted to intensive agriculture, which is irrigated mainly with water from an underground source. In the vicinity of the American River the wells are frequently sunk to a depth of from 100 to 150 feet, and are fitted with centrifugal pumps driven by gasoline, steam, or electric power. In the vicinity of Perkins and extending southward across the area, a great number of small tracts devoted to the culture of strawberries, grapes, and small fruits, are successfully irrigated by windmills, the water-bearing strata lying usually from 10 to 25 feet below the surface. Small power plants operated by gasoline, steam, or electricity are here also in use. This source of supply is capable of further development and for small tracts is fairly efficient and satisfactory.

The water used for irrigation purposes in the Sacramento area, whether derived from streams or from underground sources, is of good quality.

DRAINAGE OF SOILS.

Throughout the foothill belt and valley plain occur many small patches of poorly drained land. These are usually kept wet by springs and ravine channels supplied by natural rainfall, and are more extensive during and after the winter rains. While each usually covers only a few rods or a few acres, in the aggregate they constitute a considerable body of land. Ditches, or preferably tile-drains, would in many cases remove the excess water and prove a profitable investment, especially when such areas. as is often the case, occur in the orchard lands of the foothills.

Draintile is manufactured in large quantities at Lincoln, within the area surveyed, and should be procured at moderate prices. In the vicinity of the valley trough larger areas of deficient drainage occur, which might be greatly improved by a more extensive drainage system. These lands are, however, devoted to grain growing and warrant less expenditure, but even here, in at least many cases, the investment should prove profitable.

ALKALI IN SOILS.

The presence of alkali salts in the soils of the Sacramento area is favored by the chemical composition of the rocks from which many of the soils are derived. However, good natural drainage, coupled with a moderately heavy rainfall, as compared to other areas surveyed in California, offsets this tendency, and the soils of the area may be said to be free from alkali salts in unusual or harmful amounts. There are, however, throughout the lower valley trough and in the vicinity of the American River bottoms near Sacramento a few small, low-lying tracts in which there is a slight accumulation of the salts.

While little or no injury has as yet been experienced by alkali in this area, a more general and abundant irrigation might, by increasing capillary action and evaporation, give rise to danger upon unfavorably situated tracts. Usually the soils in which these salts have already appeared in slight amounts are of loose, open texture, and no serious trouble is apprehended. Should alkali salts occur in harmful amounts, a few underground drains and an occasional flooding would soon remove them and thereafter keep the accumulation under control.

AGRICULTURAL METHODS.

Owing to pronounced variation in topography, soils, irrigation facilities, and to the cosmopolitan character of the agricultural classes, the agricultural methods in use are quite varied. Throughout the portion of the area devoted to the growing of grain the preparation of the land is in general inadequate. Plowing, almost without exception, is done by steel gang plows and is often shallow, although it is usually more thorough than in many other grain-growing districts of the west. The land usually receives only one plowing every two or three years. The soil is given only a light harrowing or is sown without preparation other than plowing. Summer fallowing is practiced almost without exception, the land remaining idle every second year. The soil when wet is of peculiar character, running together and baking hard upon exposure, and is rendered almost useless if worked when wet. This fact, in connection with seasonal climatic conditions, greatly interferes with cultivation

and annual cropping. During the fall of the second year the seed for another crop is sown upon the unplowed stubble land and covered with an ordinary or disk harrow. The land is at this time very hard and dry, and if plowing is attempted it results only in the formation of a mass of hard, dry clods. The seed bed for the second crop is necessarily very incompletely prepared, and the yield is usually much lighter than that secured when the field is plowed. After the removal of the second crop the land is again plowed in the following spring and left during the summer as fallow land. Under this system only a portion of the land is at any one time producing crops, and conditions favoring full crops are usually obtained only once in three years. The grain is grown entirely without the aid of irrigation and is harvested by the use of modern labor-saving machinery. No commercial fertilizer and very little barnyard or stable manure is used upon these lands, although the crop yields are decreasing. A more liberal application of barnyard or stable manure and the use of green manures would undoubtedly improve the soil structure, as well as add organic matter—a much needed constituent. There seems to be no leguminous crop, however, adapted to the climatic conditions that can be grown upon these shallow soils without the aid of irrigation. The growing of alfalfa and other deep-rooted crops, which might be used in rotation with grains, is greatly restricted by the presence of the hardpan strata or underlying rocks near the surface.

On the intensively cultivated tracts devoted to orchards and vineyards the preparation and subsequent cultivation of the land are much more thorough and effective. The frequency of irrigation varies with the topography, the kind of soils, and the individual practice of the grower. With some orchards little or no irrigation is practiced until the trees come into bearing, and upon some of the heavier moisture-retaining loams grapes are successfully grown without the aid of irrigation. With the better class of fruit growers the importance of thorough and frequent cultivation of the soil during the summer season is generally recognized. The soils of the area usually possess remarkable power to retain moisture, and the practice of frequent cultivation of the soil to prevent evaporation is very effective in carrying the trees and vines through the long summer droughts. Commercial fertilizer is used only to a limited extent. Green manuring with alfalfa and clover is not at all general. This practice, as well as the use of barnyard and stable manures, is recommended. The growing of alfalfa is, however, sometimes difficult on the shallow residual soils.

The growing of berries, asparagus, hops, vegetables, and other special crops is conducted along scientific and intensive lines. In strawberry culture the land, which is well adapted to this particular fruit, but of only nominal value for general farm purposes or deep-

rooted crops, is first leveled and furrowed, the furrows being usually 3½ feet apart. The plants are set out along the furrow edges, and, forming beds between, are watered by subirrigation from the furrows. Bramble fruits and grapes are sometimes planted between the vines to replace the berry plants which at the end of four or five years usually become unproductive. The soil being underlain by the impervious hardpan, there is but little loss of water from seepage, and the system with proper means of irrigation is very successful.

Hops are grown upon permanent overhead wires or trellises, placed about 20 feet above the ground and supported by heavy posts. Asparagus is cultivated in the vicinity of Sacramento, and the early marketing of this product is said to bring handsome profits. Asparagus, beans, and other truck crops grown along the lower bottoms of the American River need little irrigation, the less favorably situated lands being supplied with small gasoline or steam pumping plants.

The dairying and stock industries, owing to natural advantages of climate and growing demands for their products, are increasing in importance. Large tracts of land lying along the lower valley plain and in the rocky and rugged southeastern portion of the area are well adapted to these industries. The native grasses are rich and nutritious. During the summer season dairy herds are commonly driven to the mountains and returned to the area in the fall. Upon the fine and deep river sediments alfalfa may be successfully grown. The quality of stock and methods for handling the output have in the past been somewhat unsatisfactory. The introduction of a better grade of stock and more modern appliances for the manufacture of dairy products would insure greater success. The raising of a limited number of mutton sheep in connection with grain and hay is to be recommneded. Small flocks can be grazed upon the hay and grain stubble lands during the most of the summer season. Upon the brush and grass covered slopes of the foothills, also, the raising of goats and sheep could be made profitable.

Upon the whole, the methods in use may be regarded as suited to the soils and conditions of the area. The advantages of thorough preparation and cultivation of the soils, however, should be more generally recognized, and the gradual adoption of a more diversified and intensive farming system on some of the extensive tracts is recommended.

AGRICULTURAL CONDITIONS.

The farming class in this area have met with failure as well as success upon both the extensive grain-producing tracts and the small farms devoted to intensive agriculture. In many ways, however, natural conditions favor success rather than failure. The area is

free from vexing alkali and seepage water problems. The winter rainfall is sufficient, with careful and thorough cultivation, to mature many crops without the aid of irrigation, and dry farming grain and hay is always certain to meet with at least partial success, there being no total failures, as is often the case under more arid conditions. With the exception of the pear blight, which threatens the pear industry, there are no unusual or dangerous plant diseases or insect pests. Citrus fruits are remarkably free from smut or scale and require but little preparation for packing.

The intensively cultivated districts have usually the appearance of prosperity and thrift. An unusual number of neat farm buildings are found here, the absence of which is often noted upon the extensively farmed tracts. Churches, schools, and other means for intellectual, moral, and social improvement are liberally provided. This condition is noted especially in the vicinity of the main foothill fruit belt and in sections devoted to the production of special crops. Neat, well-regulated towns and shipping points occur at frequent intervals. In the mining, grain, and grazing sections, however, the conditions are less satisfactory.

While the agricultural classes are in general prosperous, mortgaged lands and homes are not uncommon. Orchard and vineyard lands and those devoted to the growing of special crops are generally farmed by the individual owners, although renting of such lands is sometimes practiced. The proportion of rented land is greater in the regions devoted to grazing and to the growing of berries, vegetables, grain, and hay. According to the census of 1900 less than 50 per cent of the farms of Sacramento County were operated by their owners. The percentage is probably greater within the limits of the area surveyed, which includes portions of the counties of Sacramento, Placer, Eldorado, and Sutter. The grain, hay, and grazing tracts are rented to tenants either for cash or for a part of the crop.

While there are a few large orchards, vineyards, and hopyards operated by a single individual or corporate owners, the most of these products are grown in small tracts. The grain, grain-hay, and stock-raising lands are, however, generally held in extensive tracts or ranches, in many cases the remnants of former Spanish or Mexican land grants. One tract alone, lying on the north side of the American River, near Sacramento, and devoted exclusively to the breeding of trotting and thoroughbred horses, covers an area of about 60 square miles. Owing to these extensive holdings, and notwithstanding the great number of small orchard, vineyard, berry, and vegetable farms, the average sized farm in Sacramento County according to the last census is 480.2 acres.

The handling of teams and machinery upon the extensive grain-producing lands is done almost exclusively by white labor. Much of

the labor in picking, packing, drying, and canning the fruit is done by women and children and by Chinese and Japanese laborers. Frequently the unharvested crop is sold to Chinese or Japanese speculators, who attend to the placing of the crop upon the market. Thousands of men, women, and children enter the area for employment and camp in temporary villages during the hop-picking season, which lasts during August and September.

Much of the labor engaged in the cultivation, harvesting, and marketing of asparagus and truck crops is Chinese and Japanese, although the greater part of such crops is produced by Portuguese and Italians, who usually own or rent small tracts, and by cooperating, as is often the case, perform most of the labor themselves.

In the valley portion of the area wheat, oats, barley, and grain hay are the principal crops. Wheat is the most important grain crop, and is usually sown from the middle of October to the middle of December and harvested in June and July. In the foothills, upper valley slopes, and part of the valley plain lying immediately south of the American River, table and wine grapes, peaches, plums, cherries, pears, apricots, prunes, figs, and other deciduous as well as citrus fruits are produced in large quantities. The leading varieties of table grapes are the celebrated Flame Tokays, Muscats, Black Prince, Morocco, and Cornichon. Wineries and distilleries at Sacramento and other points in the grape-producing sections make large quantities of wine, consisting chiefly of port, sherry, angelica, claret, and brandies.

The growing of peaches of an excellent quality has been one of the most profitable and popular industries of the middle and lower foothills zone. Pears are of many varieties, the most popular being the Bartlett. Olives, both for preserving and for the oil, are grown quite extensively in the vicinity of Fairoaks and Auburn, and at other minor points. The Smyrna fig has been introduced and grown to a limited extent. Citrus fruits are grown chiefly in the vicinity of Rocklin, Valley View, Loomis, Penryn, Orangevale, and Fairoaks, but this industry is overshadowed by the grape and deciduous fruit interests.

In the vicinity of the Bear River, in the northwestern corner of the area, and of the American River, in the southwest, hop raising is conducted upon a large scale. In the berry and small fruit district, lying to the southward of the last-mentioned district, strawberries, Tokay and other table grapes, and bramble fruits are the principal crops. Asparagus, beans, tomatoes, cabbages, onions, melons, and potatoes are also important crops in the area.

The principal fruit packing and shipping points are Newcastle, Sacramento, Penryn, Loomis, Auburn, Orangevale, Fairoaks, Rocklin, Folsom City, Lincoln, and Roseville. A large proportion of the

fruits, asparagus, tomatoes, beans, and other vegetables is handled by canneries at Sacramento and at outlying points.

The adaptation of soils of certain texture and structure to special crops is usually recognized and taken advantage of in the more intensively cultivated districts. Upon the shallow, level, hardpan lands of the valley plains, grain growing has become the accepted industry, because the soil is peculiarly adapted to grains and only to a few other crops. The compact and adobelike subsoil retains the moisture from the winter rains until the maturity of the crop. Dry farming to grain upon a loose, porous, or less retentive soil would probably result in failure. The rich valley lands of moderate depth, deep alluvial sediments, and well-drained slopes of hills and upper valley margins are selected for the production of fruits and vines. Hops, beans, asparagus, and other truck crops are grown upon the fine sandy loams and the deep moist alluvial silts.

In the more thickly settled valley and foothill districts, the country roads are usually well graded and maintained in excellent condition. In the vicinity of the grain growing, mining, and grazing sections, however, there is need for better roads. With cheap electric power furnished by mountain and foothill streams, plans are on foot for the construction of rural electric railway lines through the thickly settled districts. Three lines of the Southern Pacific Railway traverse the area—the Sacramento and Placerville line, the main or Ogden line, and the Oregon line leaving the main line at Roseville. Most of the fruit goes over the main line to the East, and while the freight rates are high the shipping accommodations are generally good. In addition to the railway facilities, much bulky produce, consisting of hay, vegetables, and potatoes, is shipped cheaply by river boats from Sacramento to San Francisco and surrounding points.

Besides the local markets, San Francisco and the adjacent towns furnish excellent markets for early fruits, meats, poultry, truck crops, and dairy products. Eastern and European markets take the bulk of the fruits, while the opening of oriental and insular markets in the Far East creates a demand for vast quantities of hay, grains, beef, mutton, dairy products, and fruits, which are shipped to foreign ports of the Pacific from San Francisco.

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U.S. DEPT. OF AGRICULTURE
BUREAU OF SOILS
MILTON WHITNEY, CHIEF

SOIL MAP

CALIFORNIA
SACRAMENTO SHEET

SOIL PROFILE
(6 feet deep)

- Sierra stony loam: Sc, Gr
- Fresno gravel: Fg
- Fresno sand: S
- Fresno fine sand: Sfs, Ssc
- Fresno red sand: S, Ssc, H
- Sierra sandy loam: Ssc, S sd
- San Joaquin sandy loam: Ssc, H
- Sheridan sandy loam: Ssc, St
- San Joaquin fine sandy loam: Ssc, Sc
- Sierra clay loam: Scc, St
- Sacramento silt loam: Hsic, Scc
- Sierra loam: Sc, Scc
- Salinas gray adobe: Ad scc, Ad Ssc
- San Joaquin red adobe: Ad, H

LEGEND

- Sc Loam
- St Stone
- Sg Sand and gravel
- S Sand
- Sfs Fine sand
- Ssc Fine sandy loam
- Sandy loam
- H Hardpan
- Sd Sandy adobe
- Hsic Heavy silt loam
- Scc Clay loam
- Ad Adobe

LEGEND

- Sl Sierra stony loam
- Rs Rough stony land
- Fg Fresno gravel
- Fs Fresno sand
- Ffs Fresno fine sand
- Fr Fresno red sand
- Ss Sierra sandy loam
- SJ San Joaquin sandy loam
- Ssl Sheridan sandy loam
- SJf San Joaquin fine sandy loam
- Sc Sierra clay loam
- S Sacramento silt loam
- Slo Sierra loam
- Sg Salinas gray adobe
- Sa San Joaquin red adobe
- R Riverwash
- Gravel areas
- Rock outcrop
- Rough hilly areas

Soils Surveyed by
Macy H. Lapham, Albert S. Root and W.W. Mackie
1903–1904.

Scale 1 inch = 1 mile

Field Operations
Bureau of Soils
1904.